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CLASSIFICATION TESTING OF COMPOSITION A5
AND SELECTED PYROTECHNICS

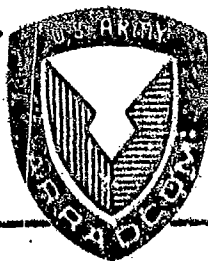
By
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PROJECT COORDINATOR
Dr. G. L. McKown

June 1978

NASA NATIONAL SPACE TECHNOLOGY LABORATORIES
Computer Sciences Corporation
Engineering and Science Services Laboratory
NSTL Station, MS 39629

Contract No. NAS13-60



US ARMY ARMAMENT RESEARCH AND DEVELOPMENT COMMAND
Technical Support Directorate
Dover, New Jersey 07801

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Composition A5 Classification Tests

R284 Tracer Mix TB 700-2

Igniter Mix I559

Sub-Igniter Mix I560

Three pyrotechnic compositions (R284 Tracer Mix, I559 Igniter Mix, and I560 Sub-Igniter Mix) and one high explosive (Composition A5) were subjected to classification tests as outlined in Chapter 3 of U. S. Army Technical Bulletin 700-2, Explosives Hazards Classification Procedure, Change 1. The results indicated that the three pyrotechnic compositions did not exhibit characteristics of a detonation, but they did not pass the impact sensitivity test. The Composition A5 high explosive exhibited characteristics of a detonation.

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FOREWORD

The ARRADCOM Resident Operations Office has conducted experiments on three pyrotechnic compositions and one high explosive composition to determine the probable hazard classifications. The investigation was conducted for the ARRADCOM Large Caliber Weapons Systems Laboratory in connection with an overall program to determine the TNT equivalency of munitions components.

The author wishes to acknowledge the technical assistance of the Hazards Test Range field crew of Computer Sciences Corporation.

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SUMMARY

Composition A5, R284 Tracer Mix, Igniter Mix I559, and Sub-Igniter Mix I560 were tested in accordance with Chapter 3 of U. S. Army Technical Bulletin 700-2, Change 1, and the results are shown in the following Table. Composition A5 exhibited characteristics of a detonation and the three pyrotechnic compositions failed to exhibit the same characteristics.

Sample Material	Detonation Test	Ignition and Unconfined Burning	Impact Sensitivity Test*	Thermal Stability	Card Gap Test
Composition A5	Explosion	No Explosion	0 at 9.53 cm 6 at 25.4 cm	No Explosion	245 Card
I560 Sub-Igniter Mix	Complete Burn	No Explosion	1 at 9.53 cm 6 at 25.4 cm	No Explosion	No Detonation
I559 Igniter Mix	Complete Burn	No Explosion	0 at 9.53 cm 2 at 25.4 cm	No Explosion	No Detonation
R284 Tracer Composition	Complete Burn	No Explosion	1 at 9.53 cm 9 at 25.4 cm	No Explosion	No Detonation

* Indicates number of explosions at each drop height.

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INTRODUCTION

BACKGROUND

Classification of bulk pyrotechnic compositions, propellants and explosives is currently accomplished by evaluation of test data obtained in accordance with Chapter 3, U. S. Army TB 700-2. Chapter 3 provides test requirements to assign hazards classification for transportation of bulk pyrotechnic compositions, propellants and explosives. These tests are designed to determine the ease of initiation and stability of bulk compositions during shipping and handling. The results of tests may be utilized by cognizant DoD/DoT agencies to assign hazards classification indices and to determine compatibility for transportation and handling.

OBJECTIVE

The objective of this study was to provide results of classification testing in accordance with U. S. Army Technical Bulletin 700-2, Change 1, on selected pyrotechnic and explosive compositions.

MATERIALS AND METHODS

TEST MATERIALS

The explosive composition tested was Composition A5, Type I high explosive [MIL-E-14970A (Mu), 6 September 1970, with amendment, lot number HOI-015-73], containing 98.5-99.0% RDX and 1.0-1.5% stearic acid.

The pyrotechnic compositions that were tested included: R284 Tracer Composition with a composition of 28% magnesium, 55% strontium nitrate, and 17% polyvinylchloride; I560 Sub-Igniter Mix with a composition of 15% polyvinylchloride, 27.5% strontium nitrate, 27.5% magnesium powder granular 12, and 30% strontium peroxide; and I559 Igniter Mix with a composition of 79.5% of I136 pre-mix (90% strontium peroxide, 10% calcium resinate) and 20.5% of pre-mix (29.3% lead dioxide, 70.7% magnesium type 3). All of the pyrotechnic compositions were shipped from Lake City Army Ammunition Plant in 4.54-kilogram quantities.

DETONATION TEST

A series of tests were performed to measure the sensitivity of the compositions to the reaction of a number 8 blasting cap. A 5.08-centimeter (2-inch) cube sample was placed on top of a perpendicular 3.81-cm (1.5-inch) diameter by 10.16-cm (4-inch) high lead cylinder. The number 8 blasting cap was placed perpendicular to, and in contact with, the top surface of the sample. A 5.08-cm (2-inch) wood cylinder with a hole drilled through its center was utilized to position and support the blasting cap. The cap was initiated by a suitable electrical current. Detonation of the sample was evidenced by deformation (mushrooming) of the lead cylinder. This test was conducted a minimum of five times, or

until detonation was evidenced, whichever was less. Observations were made to determine whether the sample exploded, burned, and/or fragmented.

IGNITION AND UNCONFINED BURNING TEST

These tests were conducted on single and multiple (four) 5.08-cm (2-inch) cube samples. For Test No. 1 (single sample test) a 5.08-cm (2-inch) cube sample was placed on a bed of kerosene-soaked sawdust which was ignited with an electrically initiated match head igniter. This test was conducted a minimum of two times. For Test No. 2 (multiple sample test) four 5.08-cm (2-inch) cube samples were placed end-to-end in a single row in contact with each other on a single bed of kerosene-soaked sawdust and ignited with an electric match head igniter at one end. This test was conducted a single time. The Ignition and Unconfined Burning Test data includes a report of occurrence of detonation or burning times of samples.

THERMAL STABILITY TEST

The samples were subjected to elevated temperatures to permit the observance of characteristic tendencies to detonate, ignite, decompose or to undergo a change in configuration under adverse storage conditions. The samples were placed in an explosion-proof oven in which the temperature was maintained at 75° C (167° F) for a period of 48 hours. Oven temperature was continuously recorded throughout the test period. Observations that were recorded included whether the test specimen exploded, ignited, and/or underwent a change in configuration such as weight loss or change in color.

IMPACT SENSITIVITY TEST

A series of 20 tests were performed to determine the sensitivity of the sample composition to mechanical shock (Impact). These tests utilize the Bureau of Explosives Impact test apparatus. A 10-mg sample was placed in the test cup, the test weight was dropped from a predetermined height, striking the sample.

The results of the 20 tests per sample, 10 at 9.5-cm (3-3/4-inch) drop height and 10 at 25.4-cm (10-inch) drop height, were reported as the number of trials exhibiting: (1) explosion, (2) decomposition, and (3) no reaction.

CARD GAP TEST

The sample materials were placed in a 13.97-cm (5.5-inch) long cold-drawn, seamless steel tube, composition 1015, having an outside diameter of 4.76 cm (1.375 inches) and a wall thickness of 0.556 cm (0.219 inch). The assembly was placed on a 15.24- by 15.24- by 0.953-cm (6- by 6- by 3/8-inch) steel witness plate in such a manner as to have a 0.159-cm (1/16-inch) air gap between the tube and the witness plate. Two pentolite pellets, 5.08 centimeters in diameter by 2.54 centimeters in height (2-inch diameter by 1-inch height) were placed directly on top of the assembly and in contact with the sample material; i.e., without the intervention of any acetate cards between the sample and pellets. (Acetate cards are used only when evidence of a detonation occurs on the first trial.) A J-2 Engineers' special blasting cap was positioned on top of the pentolite and the complete Card Gap test assembly was supported approximately 15.24 cm (6 inches) above the ground surface.

The J-2 Engineers' special blasting cap was then initiated causing detonation of the two pentolite pellets. Detonation is indicated when a clean hole is out in the witness plate. The measure of charge sensitivity is the length of attenuation (gap length) at which there is 50% probability of detonation. The charge sensitivity will be expressed in terms of 0.025-cm (0.01-inch) cards necessary for the 50% value between detonation and no detonation.

RESULTS

DATA ANALYSIS

Data analysis is based upon go/no-go results of the tests. Interpretation of the results for DoT and DoD purposes leads to the following designations:

DoT Forbidden - If the results from the Thermal Stability test indicate either an explosion, burning, or marked decomposition of the sample.

DoT Restricted - If the Impact Sensitivity tests result in an explosion at a drop height of less than 10.16-cm (4 inches).

DoT Class A (DoD Class 7) - If one or more of the following occur: (1) the Detonation Test indicates sensitivity to a No. 8 blasting cap by mushrooming the lead block; (2) the Card Gap test indicates a sensitivity value greater than 70 or more cards; (3) the Impact Sensitivity test produces an explosion above 10.16 cm (4 inches) and (4) the Ignition and Unconfined Burning test produces a detonation.

DoT Class C (DoD Class 2) - If all of the following occur: (1) the Ignition and Unconfined Burning test does not result in an explosion; (2) the Thermal Stability test does not result in an explosion, burning or marked decomposition; (3) the Detonation test does not result in an explosion and (4) the Card Gap test results in a sensitivity of less than 70 cards or no reaction at zero cards.

The preceding classification scheme is depicted in diagrammatic form in figure 1.

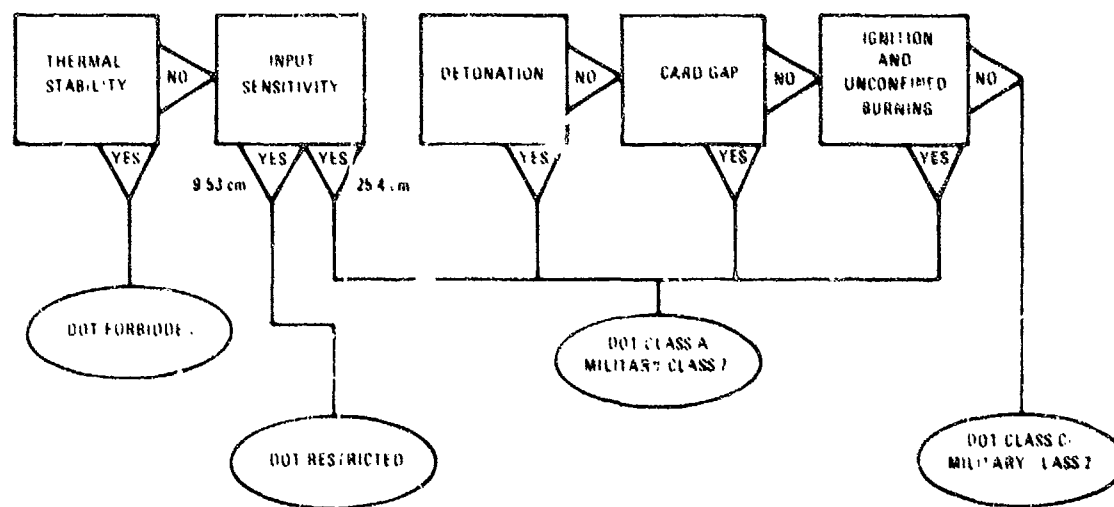


Figure 1. Interpretation of Test Results per TB700-2, Change 1.

TEST RESULTS

Data sheets for all tests are given in Appendix A. Results are shown in Table 1.

Table 1. Summary of Test Results per Chapter 3 Army Technical Bulletin 700-2, Change 1.

Sample No. (Lot)	Thermal Stability				Detonation Test				Ignition and Unconfined Burning		Average Burning Time (sec)	Impact Sensitivity				Card Gap Test			
	Explosion		Detonation		Explosion		Detonation		Explosion			Explosion		Detonation		Explosion		Detonation	
	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No		Yes	No	Yes	No	Yes	No	Yes	No
A5 (R284) (1)	X		X		X		X		X		2.5	X		X		X		X	
R284 (R284)	X		X		X		X		X		2.5	X		X		X		X	
1560 Sub-Igniter	X		X		X		X		X		2.5	X		X		X		X	
1559 Igniter Mix	X		X		X		X		X		2.5	X		X		X		X	
1560 Igniter Mix	X		X		X		X		X		2.5	X		X		X		X	

Composition A5 exhibited characteristics of mass detonation in the Detonation test by mushrooming the lead block, and a 50% value of 245 cards was recorded. Composition A5 exploded during 6 trials out of 10 at 25.4-cm (10-inch) drop height.

None of the pyrotechnic compositions exhibited characteristics of mass detonation but all three samples showed positive reactions in the Impact apparatus. R284 Tracer composition exploded once at the 9.525-cm (3-3/4-inch) height and exploded nine times at the 25.4-cm (10-inch) drop height. 1560 Sub-Igniter Mix exploded during one of 10 trials at the 9.525-cm (3-3/4-inch) height and six of 10 at the 25.4-cm (10-inch) drop height. A single explosion at the 25.4-cm (10-inch) drop height was recorded for the 1559 Igniter Mix.

DISCUSSION

Interpretation of the test results by a cognizant safety representative would probably result in a DoT Restricted classification for the 1560 Sub-Igniter Mix and R284 Tracer composition since the Impact sensitivity tests resulted in a reaction at a drop height of less than 10.16 cm (4 inches). The 1559 Igniter Mix would probably be classified as DoT Class A, Military Class 7, based upon the Impact sensitivity results. None of the pyrotechnic compositions exhibited characteristics of a mass detonating material when subjected to open flame (Ignition and Unconfined Burning Test), to intense shock and confinement (Card Gap Test), or to mild initiation to determine relative ease of initiation (Detonation Test).

Settles⁽¹⁾ Interpretation of current classification procedures designates a given material as either mass detonating (DoT Class A, DoD Class 7) or Fire Hazard (DoT Class C, DoD Class 2). By definition a pyrotechnic composition should fall in the latter category. However, the intended use of the selected pyrotechnics, as igniter and tracer mixes dictates that they must be readily ignitable with minimum energy and therefore would be expected to react at either or both of the Impact test drop heights. The test results indicated that such is the case. It should be pointed out that sensitivity to impact, however, does

not imply a tendency to mass detonate; the other tests specified in TB700-2 determines this characteristic.

Using the results of all tests, the pyrotechnic compositions showed no tendency to mass detonate. These results correlate with recent observations of McKown and Meredith⁽²⁾ which show less than 30 percent equivalencies for these materials.

CONCLUSIONS

1. Composition A5 showed characteristics of a mass-detonating material and would probably be classified as DoT Class A, DoD Class 7.
2. R284 Tracer composition and I560 Sub-Igniter Mix failed to mass detonate but did react at a 9.525-cm impact drop height and therefore would have a probable classification of DoT Restricted.
3. I559 Igniter Mix failed to mass detonate but did react at a 25.4-cm impact drop height and would therefore have a probable classification of DoT Class A, DoD Class 7.

REFERENCES

1. Settles, J. E., Deficiencies in Testing and Classification of Dangerous Material, pp 199-205, Annals of the New York Academy of Sciences, Vol. 152, Art. 1, Prevention of and Protection Against Accidental Explosion of Munitions, Fuels and Other Hazardous Mixtures, October 1968.
2. McKown, G. L. and W. E. Meredith, TNT Equivalency of R284 Tracer Composition, I560 Sub-Igniter Mix and I559 Igniter Mix, in preparation.

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APPENDIX A
TEST DATA SHEETS

Date February 19, 1973

ARRADCOM Resident Operation Office

Sponsoring Agency: NASA National Space Technology Laboratory, NSTL Station, Ms 39529

Contract No. NAS13-50

Propellant Identity (Type No.) Composition A5

Propellant Spec. MIL-E-14970A(MU) Batch HOL-015-73

Mfg. Date 1973

Detonation Test		Exploded		Burned		Fragmented	
		Yes	No	Yes	No	Yes	No
No. 8 Blasting Cap	Test I	<u>X</u>	—	<u>N/A</u>	—	<u>N/A</u>	—
	Test II	<u>X</u>	—	<u>N/A</u>	—	<u>N/A</u>	—
	Test III	<u>X</u>	—	<u>N/A</u>	—	<u>N/A</u>	—
	Test IV	<u>X</u>	—	<u>N/A</u>	—	<u>N/A</u>	—
	Test V	<u>X</u>	—	<u>N/A</u>	—	<u>N/A</u>	—

Samples: Five 5.08-cm cubes

Test: One blasting cap per sample.

Ignition & Unconfined Burning Test	Exploded		Average Burning Time, Seconds
	Yes	No	
One 5.08-cm cube	—	<u>X</u>	<u>27</u>
One 5.08-cm cube	—	<u>X</u>	<u>28</u>
Four 5.08-cm cubes	—	<u>X</u>	<u>130</u>

Samples: Six 5.08-cm cubes

Test: Ignite & burn unconfined

Thermal Stability Test	Explosion		Ignition		Change in Configuration	
	Yes	No	Yes	No	Yes	No
One 5.08-cm cube	—	<u>X</u>	—	<u>X</u>	—	<u>X</u>

Samples: One 5.08-cm cube

Test: 48 hours at 75° C in vented oven.

Card Gap Test	Detonation	50% Value	<u>245</u>	(No. of Cards)	<u>280</u>
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Impact Sensitivity Test

Bureau of Explosives Impact Apparatus

9.5 cm (3.75")			25.4 cm (10.0")		
10 Trials			10 Trials		
No. of Trials Exhibiting			No. of Trials Exhibiting		
Explosion Flame and Noise	Decomposition Smoke	No Reaction No Smoke No Noise	Explosion Flame and Noise	Decomposition Smoke	No Reaction No Smoke No Noise
0	0	10	6	0	4

Approved:

Test Director _____

Test Department Head _____

Assigned Classification

DOD Approval

ICC Forbidden	<input type="checkbox"/>
ICC Restricted*	<input type="checkbox"/>
ICC Class A	<input type="checkbox"/>
ICC Class B	<input type="checkbox"/>

Signature _____

Title _____

Organization _____

*Shipping instructions are to be requested from ICC (para 3-13A (2)).

Date March 13, 1978

Sponsoring Agency ARRADCOM Resident Operation Office
NASA National Space Technology Laboratory, NSTL Station, Ma 38529

Contract No. NAS13-50

Propellant Identity (Type No.) R284 Tracer Composition

Propellant Spec. _____ Batch _____

Mfg. Date _____

Detonation Test

		Exploded		Burned		Fragmented	
		Yes	No	Yes	No	Yes	No
No. 8 Blasting Cap	Test I	—	X	—	X	N/A	—
	Test II	—	X	—	X	N/A	—
	Test III	—	X	—	X	N/A	—
	Test IV	—	X	—	X	N/A	—
	Test V	—	X	—	X	N/A	—

Samples: Five 5.08-cm cubes

Test: One blasting cap per sample.

Ignition & Unconfined Burning Test

		Exploded		Average Burning
		Yes	No	Time, Seconds
One 5.08-cm cube		—	X	24.9
One 5.08-cm cube		—	X	23.5
Four 5.08-cm cubes		—	X	26.8

Samples: Six 5.08-cm cubes

Test: Ignite & burn unconfined

Thermal Stability Test

		Explosion		Ignition		Change in Configuration	
		Yes	No	Yes	No	Yes	No
One 5.08-cm cube		—	X	—	X	—	X

Samples: One 5.08-cm cube

Test: 48 hours at 75°C in vented oven.

Cord Gap Test No Detonation

50% Value 0 (No. of Cords) 0

Impact Sensitivity Test

Bureau of Explosives Impact Apparatus

9.5 cm (3.75")			25.4 cm (10.0")		
10 Trials			10 Trials		
No. of Trials Exhibiting			No. of Trials Exhibiting		
Explosion	Decomposition	No Reaction	Explosion	Decomposition	No Reaction
Flame and	Smoke	No Smoke	Flame and	Smoke	No Smoke
Noise 1	No Noise 0	No Noise 9	Noise 9	No Noise 0	No Noise 1

Approved:

Test Director _____

Test Department Head _____

Assigned Classification

DDO Approval

ICC Forbidden	
ICC Restricted*	
ICC Class A	
ICC Class B	

Signature _____

Title _____

Organization _____

*Shipping instructions are to be requested from ICC (para 3-13A (2)).

Date March 15, 1978
ARRADCOM Resident Operations Office
Sponsoring Agency NASA National Space Technology Laboratory, NSTL Station, Ms 39529

Contract No. NAS13-50

Propellant Identity (Type No.) I560 Sub-Igniter Mix

Propellant Spec. _____ Batch _____

Mfg. Date _____

Detonation Test

		Exploded		Burned		Fragmented	
		Yes	No	Yes	No	Yes	No
No. 8 Blasting Cap	Test I	—	X	X	—	N/A	—
	Test II	—	X	X	—	N/A	—
	Test III	—	X	X	—	N/A	—
	Test IV	—	X	X	—	N/A	—
	Test V	—	X	X	—	N/A	—

Samples: Five 5.08-cm cubes

Test: One blasting cap per sample.

Ignition & Unconfined Burning Test

	Exploded		Average Burning
	Yes	No	Time, Seconds
One 5.08-cm cube	—	X	12.9
One 5.08-cm cube	—	X	13.3
Four 5.08-cm cubes	—	X	14.5

Samples: Six 5.08-cm cubes

Test: Ignite & burn unconfined

Thermal Stability Test

	Explosion		Ignition		Change in Configuration	
	Yes	No	Yes	No	Yes	No
One 5.08-cm cube	—	X	—	X	—	X

Samples: One 5.08-cm cube

Test: 48 hours at 75° C in vented oven.

Card Gap Test No Detonation

50% Value 0 (No. of Cards) 0

Impact Sensitivity Test

Bureau of Explosives Impact Apparatus

9.5 cm (3.75")			25.4 cm (10.0")		
10 Trials			10 Trials		
No. of Trials Exhibiting			No. of Trials Exhibiting		
Explosion	Decomposition	No Reaction	Explosion	Decomposition	No Reaction
Flame and	Smoke	No Smoke	Flame and	Smoke	No Smoke
Noise 1	No Noise 2	No Noise 7	Noise 6	No Noise 0	No Noise 4

Approved:

Test Director _____

Test Department Head _____

Assigned Classification

DDO Approval

ICC Forbidden	
ICC Restricted*	
ICC Class A	
ICC Class B	

Signature _____

Title _____

Organization _____

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Date March 16, 1978

ARRADCOM Resident Operations Office

Sponsoring Agency NASA National Space Technology Laboratory, NSTL Station, Ms 39529

Contract No. NAS13-50

Propellant Identity (Type No.) I559 Igniter Mix

Propellant Spec. _____ Batch _____

Mfg. Date _____

Detonation Test

		Exploded		Burned		Fragmented	
		Yes	No	Yes	No	Yes	No
No. 8 Blasting Cap	Test I	—	X	X	—	N/A	—
	Test II	—	X	X	—	N/A	—
	Test III	—	X	X	—	N/A	—
	Test IV	—	X	X	—	N/A	—
	Test V	—	X	X	—	N/A	—

Samples: Five 5.03-cm cubes

Test: One blasting cap per sample.

Ignition & Unconfined Burning Test

	Exploded		Average Burning
	Yes	No	Time, Seconds
One 5.08 cm cube	—	X	7
One 5.08-cm cube	—	X	12
Four 5.08-cm cubes	—	X	13.5

Samples: Six 5.08-cm cubes

Test: Ignite & burn unconfined.

Thermal Stability Test

		Explosion		Ignition		Change in Configuration	
		Yes	No	Yes	No	Yes	No
One 5.08-cm cube		—	X	—	X	—	X

Samples: One 5.08-cm cube

Test: 48 hours at 75° C in vented oven.

Card Gap Test **No Detonation**

50% Value 0 (No. of Cards) 0

Impact Sensitivity Test

Bureau of Explosives Impact Apparatus

9.5 cm (3.75")			25.4 cm (10.0")		
10 Trials			10 Trials		
No. of Trials Exhibiting			No. of Trials Exhibiting		
Explosion Flame and Noise 0	Decomposition Smoke No Noise 0	No Reaction No Smoke No Noise 10	Explosion Flame and Noise 2	Decomposition Smoke No Noise 0	No Reaction No Smoke No Noise 8

Approved:

Test Director _____

Test Department Head _____

Assigned Classification

DOD Approval

ICC Forbidden	
ICC Restricted*	
ICC Class A	
ICC Class B	

Signature _____

Title _____

Organization _____

*Shipping instructions are to be requested from ICC (para 3-13A (2)).